PATENT SPECIFICATION

DRAWINGS ATTACHED

937,623

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COMPLETE SPECIFICATION

Improvements in or relating to the Evaporation of Sea Water

We, THE BADGER COMPANY, INC., formerly BADGER MANUFACTURING COMPANY, a corporation organised under the laws of the State of Massachusetts, United States of America, of Cambridge, State of Massachusetts, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the evaporation of sea-water and pertains more specifically to a method and apparatus for distilling sea-water having a high output of distillate with a minimum heat and power input.

A variety of systems has hitherto been proposed for the evaporation or distillation of sea-water. All such systems suffer from the disadvantage, among others, that a large quantity of heat or power or both is required to produce a given amount of fresh water distillate, leading to high cost of operation.

An object of the present invention is to provide apparatus for and a method of sea-water evaporation having high efficiency, in which at least ten pounds of distillate are produced for each pound of steam used for heat and power.

Specifically, the present invention provides apparatus for distillation of sea-water, wherein a vapour compression evaporator is provided including an evaporator chamber, a compressor for compressing the vapour evolved and a heat exchanger, the compressed vapour passing through a first side of said heat-exchanger to condense said vapour whilst a pump recirculates a portion of the unevaporated feed to said evaporator chamber through a second side of the heat exchanger, gas removal and evaporation means being provided for substantially removing the non-condensible gases from said sea water prior to its introduction into said evaporator chamber, some of the sea-water being evaporated during removal of the non-condensible gas.

The present invention also provides a method of distilling sea-water, comprising the steps of reducing the content of non-condensible gas in the sea-water to less than 1% by volume of the total volume of gas in the sea water, evaporating a portion of said sea-water at a maximum temperature of 175° F., compressing the vapour evolved at a ratio below 1.25, and condensing the compressed vapour to form a distillate product by passing it in heat exchange relationship with a recirculating portion of unevaporated sea-water, the ratio of recirculating feed to distillate product being above 200, some of the sea-water being evaporated during reduction of the non-condensible gas content.

The drawing is a schematic representation of one embodiment of the present invention.

As shown in the drawing, there is provided a vapor compression evaporator unit which includes an evaporator chamber 10, a heat exchanger or condenser 11, a compressor 12 driven by steam turbine 14, and a recirculating pump 16 driven by steam turbine 18. A steam ejector 40 is provided to remove residual non-condensible gases from the condenser 11 through line 42.

In place of the auxiliary heaters normally used to preheat the feed stream to a vapor compression evaporator, there is provided a multiple-stage flash evaporator having evaporator chambers 20, 22, 24, 26, 28, 30 with each of which is associated a condenser 21, 23, 25, 27, 29 and 31, and an auxiliary heat exchanger 50. The sea-water feed enters through intake 60 and passes in turn through the several condensers 21, 23, 25, 27, 29 and 31 where it is heated by the vapors in each chamber from its initial temperature of 80° F. to a temperature of 152° F. From condenser 31 the sea-water feed passes to one side of heat exchanger 50, to the other side

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of which is supplied through lines 52, 54, 56 the exhaust steam from steam ejector 40 as well as that from turbines 14 and 18 which serve as prime movers for compressor 12 and recirculation pump 16 respectively. The steam condensate from heat exchanger 50 is returned to the steam supply boiler by means of pump 70 through line 72.

The sea-water feed, which leaves heat exchanger 50 at a temperature of 172° F. is then carried by valved line 34 to chamber 30 where it is flashed to deaerate it, the non-condensible gases being drawn off through line 43 which connects condensers 31 with line 42. A valve is provided in line 43 to permit control of the pressure in chamber 30 and hence control of the temperature of the unevaporated feed which contains less than 1% non-condensible gas by volume of the total volume of gas in the sea-water feed and which is passed through line 80 and pump 81 to the evaporating chamber 10 of the vapor compression unit, entering, in the preferred embodiment which is illustrated, at a temperature of 160° F.

The vapors from chamber 10 are compressed by compressor 12, the condensed in the first side of condenser 11. The compression ratio must not exceed 1.25, usually being from 1.1 to 1.25. Condensed vapor or distillate from condenser 11 passes to condenser 29 of the multiple-stage evaporator through line 32, where it is mingled with distillate from chamber 28 as well as that from condenser 31.

A portion of the unevaporated feed in chamber 10 is constantly recirculated by pump 16 through line 82 and the second side of condenser 11 back to chamber 10. A small fraction of this unevaporated feed is simultaneously withdrawn from the recirculating stream through valved line 84 to the bottom of chamber 28. The distillate from each stage of the flash evaporator is condensed in its respective condenser 29, 27, 25, 23, 21 and then combined with the distillate from the next successive condenser, the distillate from the last condenser 21 being withdrawn by pump 100 at a temperature of 100° F. The residue from each chamber 28, 26, 24, 22 of the flash evaporator is flashed in the next successive chamber at successively lower temperatures, the residue from the last chamber 20 being withdrawn by pump 102 at a temperature of 100° F.

The successively lower pressures required for flashing in each chamber are provided by valved lines 44, 45, 46, 47 and 48, each of which connects one of condensers 29, 27, 25, 23, 21 to line 42 for removal of non-condensible gases, in the usual manner.

The steam supply for the apparatus is introduced through line 86 from any suitable pressure source, being supplied in the embodiment illustrated at a gauge pressure of 450 pounds per square inch and a temperature of 600° F.

The extremely high efficiency which is attainable by means of the foregoing system is clear from the fact that with a total input of 7860 pounds of steam per hour to the ejector and to the two turbines 14, 18, it is possible to process 380,000 pounds of sea-water per hour, pump 16 being operated to provide a recirculation rate of 46,000 gallons per minute, while 83,400 pounds per hour (167 gallons per minute) of distillate product are withdrawn from the vapor compression unit through line 32, the recirculation-product ratio thus being 276. Under these conditions 105,000 pounds of fresh-water distillate per hour are provided, of which 79.5% comes from the vapor compression unit, the remainder coming from the flash evaporator. This amounts to 13.3 pounds of distillate for each pound of steam input. It should be noted that the maximum temperature to which the sea-water is subjected in this system is only 172° F., a temperature below the 175° F. maximum above which scaling begins to be objectionable.

While conditions of operation may be varied somewhat from those of the preferred embodiment illustrated and described above, best results are obtained by operating under such conditions that the maximum temperature attained by the sea water is 175° F.; by maintaining the compression ratio in the vapor compression unit below 1.25, usually from 1.1 to 1.25; and by maintaining the ratio of recirculation to distillate product in the vapor compression unit above 200, so that at least ten pounds of distillate are produced for each pound of steam input.

WHAT WE CLAIM IS:—

1. Apparatus for distillation of sea water, wherein a vapour compression evaporator is provided including an evaporator chamber, a compressor for compressing the vapour evolved and a heat exchanger, the compressed vapour passing through a first side of said heat-exchanger to condense said vapour whilst a pump recirculates a portion of the unevaporated feed to said evaporator chamber through a second side of the heat-exchanger, gas removal and evaporation means being provided for substantially removing the non-condensible gases from said sea water prior to its introduction into said evaporator chamber, some of the sea water being evaporated during removal of the non-condensible gas.

2. Apparatus according to claim 1, wherein the gas removal means includes a flash evaporator.

3. Apparatus according to claim 2, wherein the flash evaporator has a multiple number of stages, each having an evaporating chamber and a condenser, the sea water first entering the first-stage evaporating chamber for

removal of non-condensible gases therefrom and for evaporation of a portion thereof, the unevaporated feed from said first-stage evaporating chamber being passed to said vapour compression evaporator whilst condensate from the first-stage condenser is passed to the second-stage condenser to combine with the condensate of said second-stage condenser, the condensed vapour from the heat-exchanger of said vapour compression evaporator being passed to said second-stage condenser to combine with the first- and second-stage condensates whilst a second portion of the unevaporated feed from said vapour compression evaporator is passed to the second-stage evaporating chamber of said flash evaporator, the condensate from the second and each subsequent stage of the flash evaporator being passed to the condenser of the next successive stage whilst the unevaporated feed from the chamber of the second and each subsequent stage is passed to the chamber of the next successive stage.

4. Apparatus according to claim 3, wherein the sea-water feed is preheated by passing it through the cooling sides of the condensers of the flash evaporator in a flow direction opposite to that of the condensate.

5. Apparatus according to claim 4, wherein an auxiliary heat exchanger is provided, through one side of which the preheated sea-water feed is passed to the first-stage evaporating chamber of said flash evaporator, a second side of said auxiliary heat exchanger receiving exhaust steam from an ejector which aids the flash evaporator in the removal of said non-condensible gases and from a turbine which drives the compressor of the vapour compression evaporator.

6. A method of distilling sea-water, comprising the steps of reducing the content of non-condensible gas in the sea-water to less than 1% by volume of the total volume of gas in the sea water, evaporating a portion of said sea-water at a maximum temperature of 175° F., compressing the vapour evolved at a ratio below 1.25, and condensing the compressed vapour to form a distillate product by passing it in heat exchange relationship with a recirculating portion of unevaporated sea-water, the ratio of recirculating feed to distillate product being above 200, some of the sea water being evaporated during reduction of the non-condensible gas content.

7. A method according to claim 6, wherein the reduction of the content of non-condensible gas in the sea-water is effected by flash evaporation, the vapor evolved during said flash evaporation being condensed and thereafter combined with said distillate product, the residual unevaporated sea-water obtained from said flash evaporation and the vapour-compression type evaporation being subjected to further flash evaporation in a plurality of successive stages in each of which the vapor evolved is condensed and added to the previously combined vapor and distillate product.

8. A method according to claim 7, wherein said sea-water is preheated prior to the initial flash evaporation step by passing it in heat exchange relationship countercurrent to the combined condensate and distillate product through the stages of flash evaporation.

9. Apparatus for distillation of sea-water, constructed and arranged substantially as herein described, with reference to the accompanying drawing.

10. A method of distilling sea-water, substantially as herein described.

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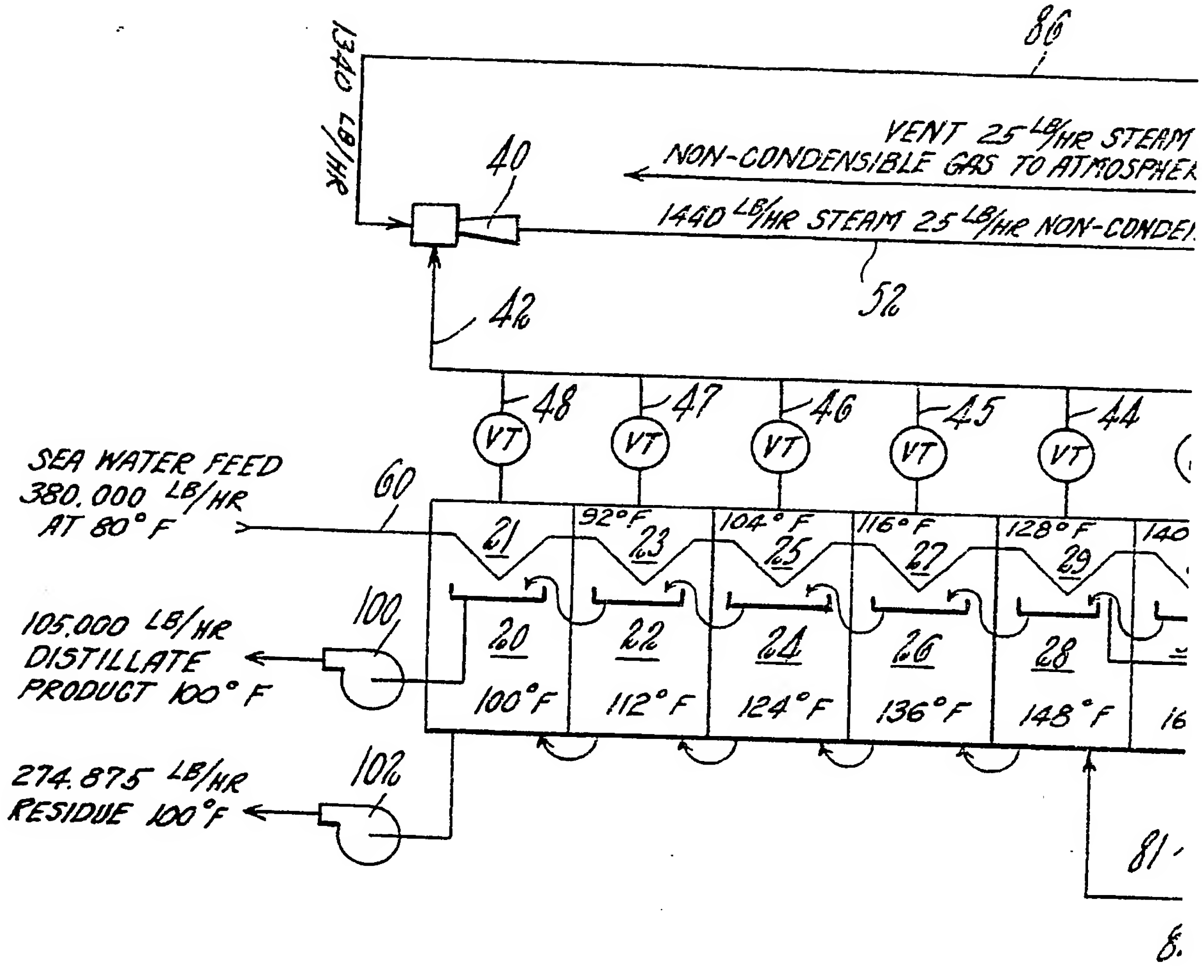

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1 SHEET

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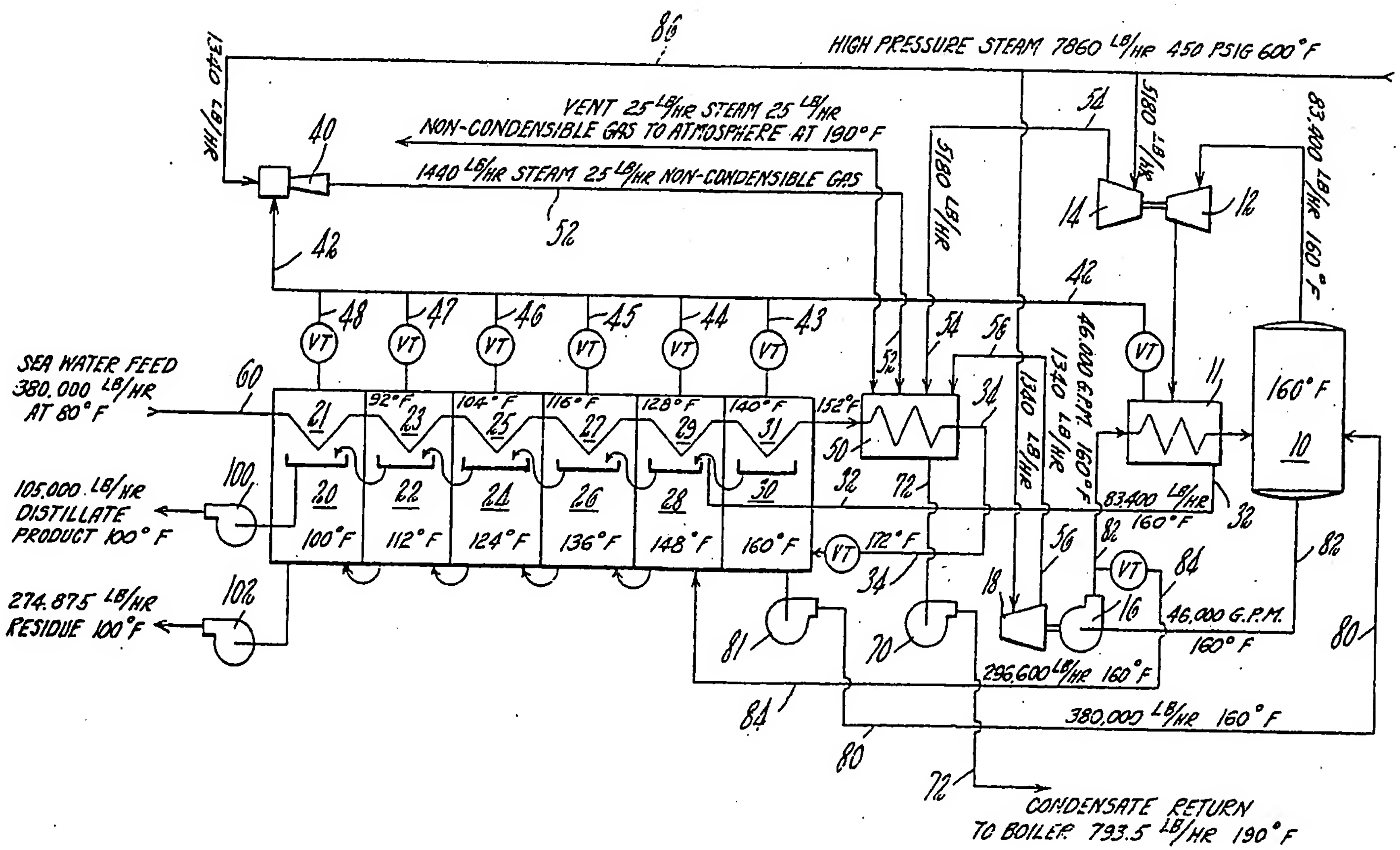

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